Communications Assessment Model (CAM): Processes and Products Associated with Modeling, Simulation and Assessment of DOD Networks

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Network chokepoints

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The CAM process of assessing DOD networks is also applicable for assessing the bandwidth burdens for the medical and intelligence communities' networks during times of conflict or other surge conditions.

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13. ABSTRACT *(Maximum 200 words)*
The CAM process is a communications assessment and modeling tool that evaluates the impact of communications demands on current and evolving theater-level Defense Information Infrastructure/Defense Information Systems Network (DII/DISN) communications networks and systems supporting the CINCs, Joint Staff, and OSD. The CAM process can identify critical communication nodes and links requiring performance improvement and can answer "what-if" questions in the event of node failures. It provides performance analyses on data, voice, and video communications network links during different stages of various scenarios ranging from Major Theater War (MTW) and Small Scale Contingency (SSC) to Non-combatant Evacuation Operations (NEO). The CAM process is tailored to address specific assessment requirements for each network involved in a particular scenario with respect to its adequacy to support hostilities in a CINC's area of responsibility (AOR). The CAM process provides DOD warfighters and planners with knowledge regarding where additional attention is needed to resolve areas of communications defiencies or imbalances. CAM has been used successfully to assess (1) the adequacy of DII/DISN networks in supporting CINC Operational Plans and Contingency Plans and (2) the impact of emerging technologies, such as the Enhanced Mobile Satellite System and the Global Broadcast Service, on the DII/DISN networks.

14. SUBJECT TERMS
Communications Assessment Model (CAM), Modeling Simulation and Assessment (MS&A) Global Broadcast Service (GBS), Enhanced Mobile Satellite System (EMSS), Joint Warfare System (JWARS), Information Exchange Requirements (IER), Network Congestion.

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ABSTRACT

DEFENSE INFORMATION SYSTEMS AGENCY
COMMUNICATIONS ASSESSMENT MODELING
IN SUPPORT OF THE WARFIGHTER

The C4I Modeling, Simulation and Assessment (MS&A) Directorate, CINC Support Division (D82) of the Defense Information Systems Agency (DISA) has developed and is employing the Communications Assessment Model (CAM), a unique large scale communications assessment and modeling process. This process is used to determine the adequacy of current and evolving theater-level communications networks and systems to support ambient peacetime traffic and the projected activity required during operational, wartime, and contingency scenarios as promulgated by the theater Commanders-in-Chief (CINCs). During the period 1996-1998, the D82 CAM team delivered unprecedented analyses and reports to several customers on major voice, data, and video circuits comprising Defense Information Systems Networks (DISN) as well as impact assessments on planned systems, including the Global Broadcast Service (GBS) and the Enhanced Mobile Satellite System (EMSS). Specifically, CAM developed and delivered (1) assessments for the U.S. Southern Command (USSOUTHCOM) which determined the optimum communications infrastructure needed for counternarcotics and Operations Other Than War (OOTW) scenarios; (2) DISN performance assessments for the U.S. Pacific Command (USPACOM) for Single Small Scale Contingency and Major Theater War scenarios; (3) DISN performance assessments for the U.S. Central Command (USCENTCOM) for a "Desert Storm" type scenario in Southwest Asia (SWA); (4) Defense Switched Network impact analyses for EMSS implementation in the USPACOM area of responsibility (AOR); (5) a SIPRNET and NIPRNET impact assessment for GBS in the USPACOM AOR; and (6) the warfighter communications modules for the Joint Warfare System (JWARS), a theater-level campaign model being developed by the Office of the Secretary of Defense (Program Analysis & Evaluation) through the JWARS Program Office.

CAM was successful in identifying critical communication nodes and links requiring performance improvement; answering customers' "what-if" questions in the event of selected node failures; and providing detailed, time-domain performance analyses on data and voice communication network links during different stages of a scenario. CAM is recognized as a key assessment tool for DISA to support the CINCs, Joint Staff, and Office of the Secretary of Defense (OSD).

The main modeling component of CAM is "COMNET III," a commercial simulation product developed by CACI, Inc. With this product, CAM is able to perform quick, accurate analysis and produce reports on specific performance metrics (e.g., network link utilization, message speed of service, message transfer rates, and probability of call blocking) for specific users and networks.

Communications Assessment Model

The Communications Assessment Model is an analytical modeling, simulation, and assessment (MS&A) process that evaluates the impact of communications demands on communications networks. CAM is used to identify data traffic congestion and chokepoints and their impact on information flows, as well as blocking probabilities associated with voice communications [Figure 1]. The information demands associated with the Department of Defense (DOD) voice, data, and video networks come from actual "peacetime" traffic and projections of "wartime" surge traffic. In the CAM process, ambient peacetime communications traffic loads are derived from network probes, and wartime information products are characterized by communication transmission parameters called Information Exchange Requirements (IERs). An IER is the representation of a data, voice, or video product to be transmitted over a communications link. A single IER consists of a record of data fields to describe a product's size in kilobytes, the transmission source and destination identifications, the time of day for transmission, the length of call time (voice), the frequency of transmissions, the message classification and precedence, and the network involved (e.g., SIPRNET). The CAM process also develops the network topology models for a commercially available, discrete event network simulation (COMNET III). The IER traffic is used as input to run the simulation, from which network performance assessments are then produced [Figure 2].

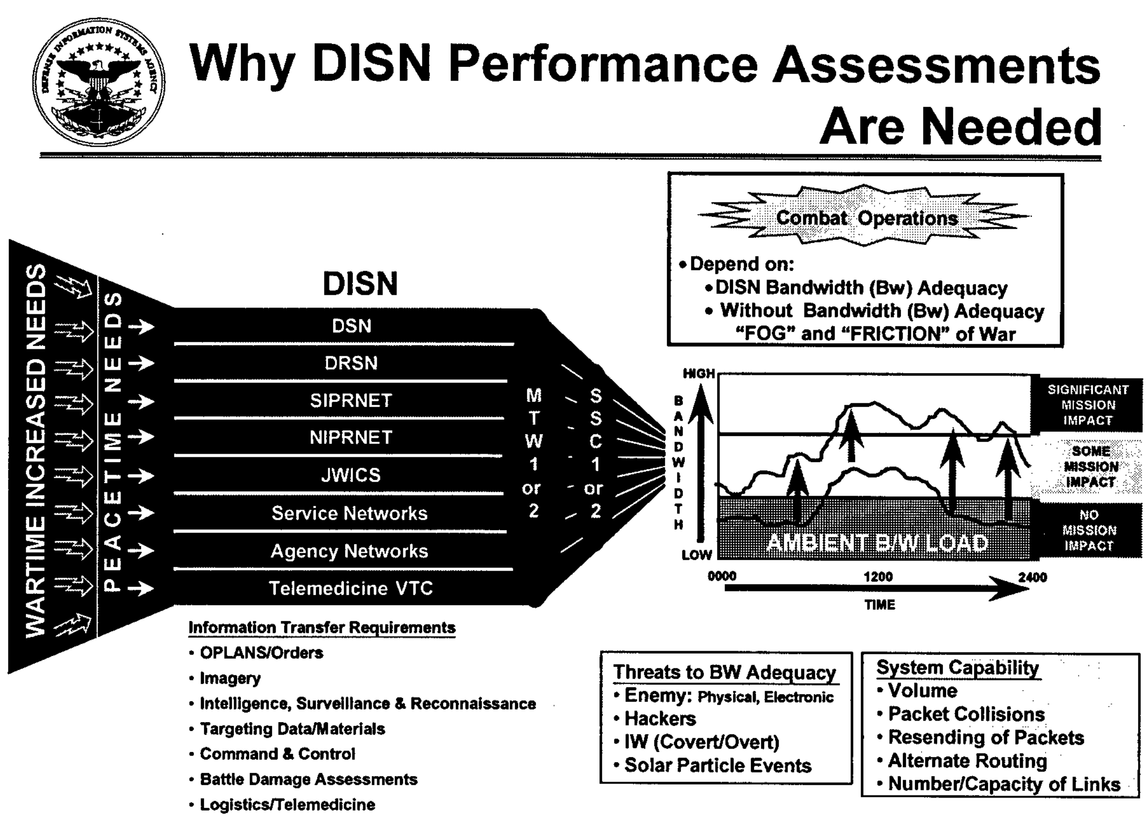

Figure 1.

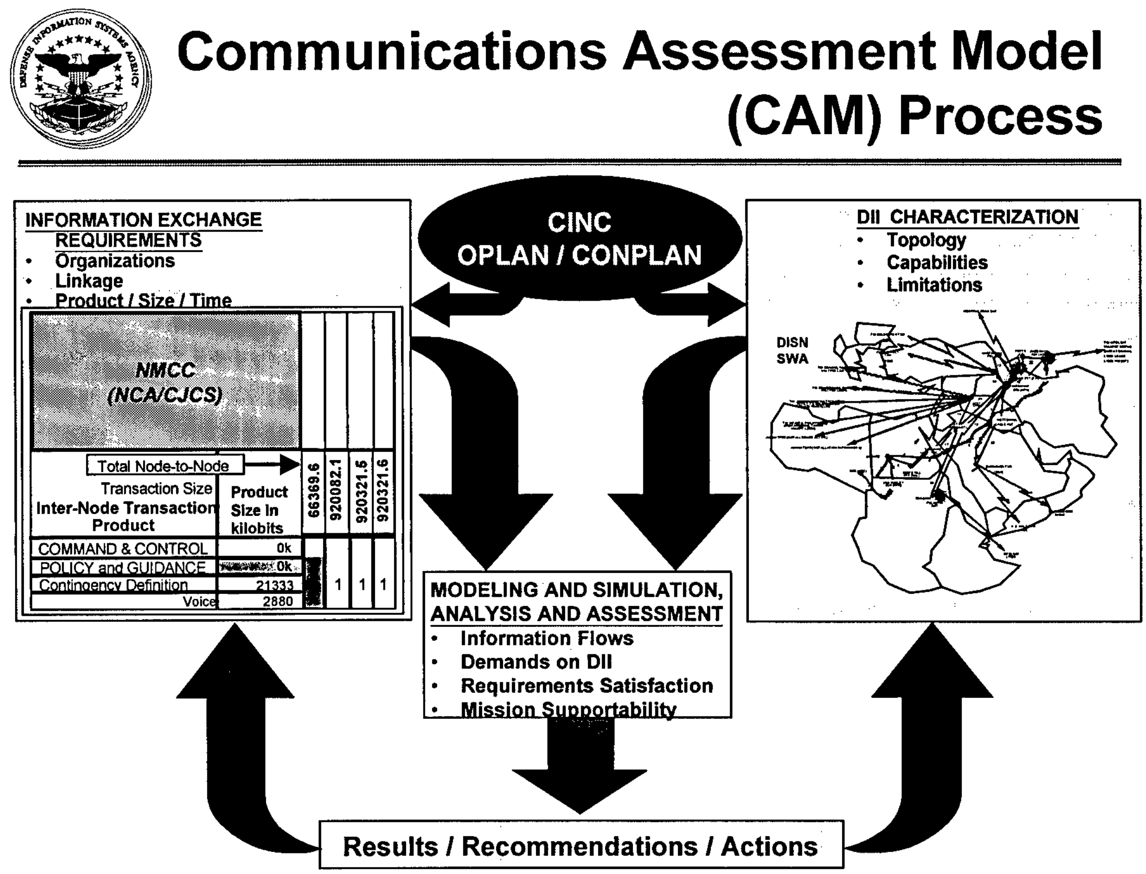

Figure 2.

CAM is the DISA modeling tool used to provide network impact analyses concerning the introduction of new C4I technologies and systems into a CINC area of responsibility (AOR). For example, CAM has been used to assess the impact of the Enhanced Mobile Satellite System (EMSS), which is the DOD implementation of voice communications using the Iridium satellite system, and the Global Broadcast Service (GBS), which is a system of uplink sites, satellites, receive terminals and management processes for military communications broadcasts. CAM is also used to determine the adequacy of Defense Information Infrastructure (DII) networks to satisfy CINC Operational Plan (OPLAN) and Contingency Plan (CONPLAN) scenarios. The CAM process is tailorable to evaluate specific information requirements for each network involved in a particular scenario with respect to its adequacy to support the mission, tasks, and activities in a CINC's AOR. CAM has been used, for example, to assess the adequacy and shortfalls of communications for varied scenarios including Major Theater War (MTW), dual-MTW, Single Small Scale Contingency (SSC), and Non-combatant Evacuation Operations (NEO).

OPLAN and CONPLAN Communications Assessments

When an OPLAN or CONPLAN is developed, the numbers of aircraft, ships, and ground forces that are required to support scheduled military activities and movement are carefully

considered. The CAM process provides DOD senior managers and developers with a state-of-the-art means of assessing whether the plans generate communications needs that exceed the capacities of existing or planned communications networks for the particular geographic area under consideration.

For example, a recent USCINCPAC MTW CAM assessment examined the effectiveness of eight different networks spanning Asia, the Central Pacific, and CONUS in support of a USCINCPAC OPLAN during each of six scenario events. The assessment focused on the current communications architecture, and also considered the introduction of GBS. The time-phased performance of the networks with respect to the exchange and distribution of text, image, video, graphics, data, and voice message products was determined as a result of this assessment. Initially, IER records needed to be developed for each message product and communications requirement, which involved close coordination with the user community for accuracy and quality control. Next, the CAM team developed network topology models for the COMNET III simulation, representing the communications infrastructure required by the particular scenario. This involved close liaison with several DISA offices to obtain the required link parameter and node data. Then, specific IERs were used as input during selected simulation runs, which computed communications measures of effectiveness such as link utilization, speed of service (message delay), and message transfer rate. For this particular assessment effort, the CAM team, led by D82 government project managers and comprised of contractors from Science Applications International Corporation (SAIC) and the MITRE Corporation, was jointly supported by operational experts at the DISA-Pacific Field Office, USCINCPAC Headquarters, and the military service components. Final deliverables to the customer included a detailed PowerPoint presentation and an animation product showing selected communications performance parameters over time.

Another recent CAM assessment examined the adequacy of communications for a "Desert Storm" type scenario in Southwest Asia. The U.S. Central Command (USCENTCOM J6) requested this CAM assessment to verify whether planned systems will satisfy the communications requirements for a USCENTCOM OPLAN scenario. The information products and deliverables were similar to those of the USCINCPAC assessment described in the preceding paragraph.

In certain DOD networks, where the results of assessing an existing OPLAN or CONPLAN indicate unacceptable delays, congestion, or blockage, CAM provides the level of detail needed to allow identification of the specific links where vitally important command and control information may be delayed from reaching its destination.

Combat operations depend heavily on DII/DISN bandwidth adequacy. A deficiency in the critical bandwidth needed for wartime operations directly contributes to the "fog and friction" of war. CAM is a proven MS&A process available to operational military commanders to proactively determine, through the use of selected simulation tools, the points of network congestion or failure that would occur during wartime, contingency, exercise, or peacetime operations, so that alternative or preventative measures can be identified and executed when needed. The assessment results also provide senior DOD managers with the knowledge needed to plan and implement network upgrades or changes to compensate for predicted future deficiencies. CAM readily provides the warfighter community with the capability to accurately predict and determine the adequacy of the DII/DISN during contingency situations.

Unique and Ad-hoc Assessments

CAM is a versatile, robust, reliable, and replicable process that can provide accurate information about a network's performance in a variety of situations. For example, it can determine the impacts to command and control links if a major communications node is adversely affected through terrorism, information warfare, combat losses, or natural disasters (e.g., earthquakes, lightning strikes/fires). CAM can assess how each network is impacted when a selected link operates under less than optimal conditions [Figure 3]. CAM is also able to assess how redirected traffic would flow and, more importantly, its impact (e.g., additional delays) on the remaining network.

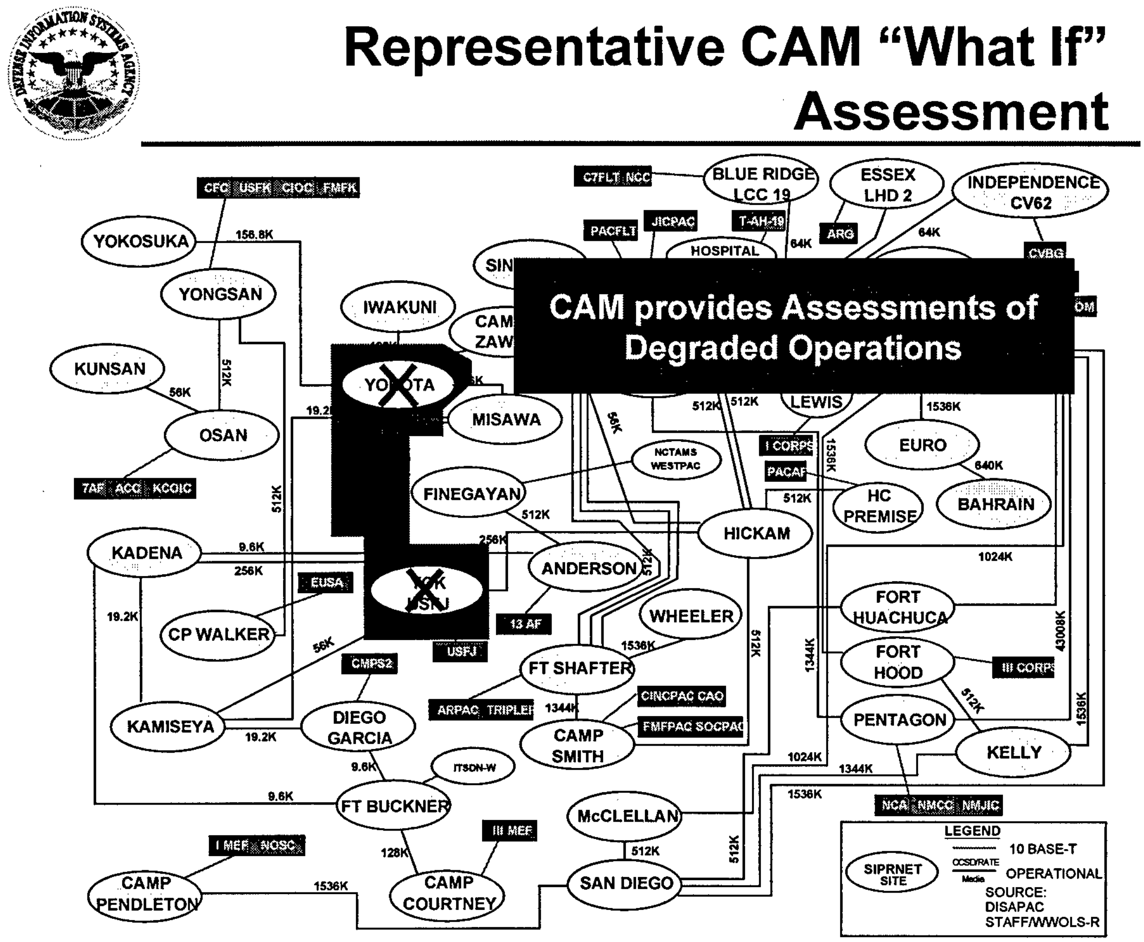

Figure 3.

CAM results can reflect individual or aggregated network performance (for the entire collection of voice, video, and data networks in the CINC's AOR). These results provide the CINC, J6, DISA, and DISA Field Offices with an important "overall view" of current or future communications in an AOR with respect to a particular scenario. The results can be color coded

(green, yellow, or red) for an executive overview of mission supportability by each combat event [Figure 4]. (Note: CAM also provides a detailed color-coded, animation output that runs on a PC or laptop.) There is no other currently available DOD model that is able to provide this important theater-wide communications assessment information for both peacetime and wartime conditions.

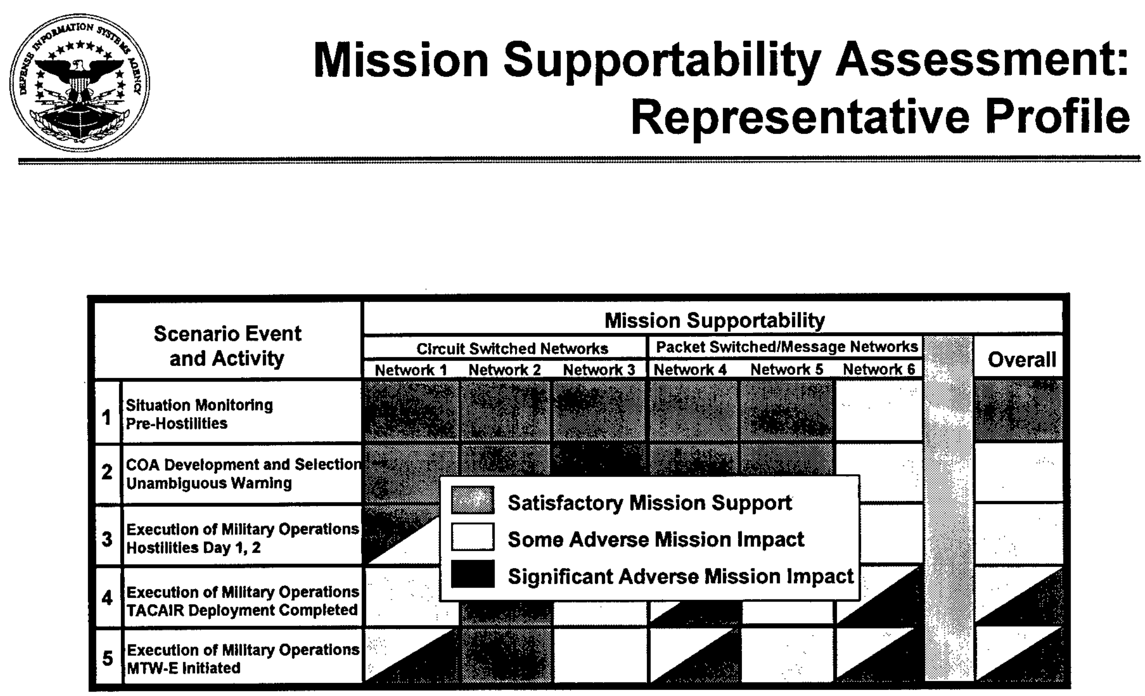

Figure 4.

<u>CAM as an Operational and Business Decision Aid</u>

CAM assessment results provide the necessary information to make informed decisions about circuit planning, infrastructure upgrades, link utilization and optimization, and bandwidth management for peacetime, wartime, contingency, and operational exercise scenarios. A network owner must be able to provide cost-effective communications services to the circuit user while ensuring quality of service and survivability. CAM can interface with a number of commercially available tariff software products to develop customer-focused, cost-benefit analyses.

Just as the wartime "cargo capacity" of aircraft and ships is carefully examined to ensure that the cargo needs in an OPLAN/CONPLAN are not exceeded, CAM is used to examine the utilization of existing network link "communications capacity" and identify over- and under-utilized links. Planners and CINC staffs can then use this data to determine the best operational and business practices and make appropriate changes (e.g., purchasing and installing equipment to increase capacity only where needed). CAM is a key DISA process that provides the knowledge from which informed decisions can be made to address communications inadequacies or imbalances in a CINC AOR. The "capacity versus demand" knowledge that CAM provides is

a critical component in a circuit owner's cost-benefit analysis for optimizing peacetime and wartime communications for the CINCs, military services, and DOD agencies.

CAM Components

CAM is an analytic method comprised of two major components for assessing the impact of explicit traffic loading on specific network topologies. One component of CAM identifies the type of product being generated (i.e., data, voice, video, etc.) and the profile of how that product is transferred from source to destination. The characterization of a data, voice, or video product to be transmitted over a communications link is called an Information Exchange Requirement (IER). A single IER consists of data fields to describe a product's size in kilobytes, the transmission source and destination identifications, the time of day for transmission, the length of call time (voice), the frequency of transmissions, classification, precedence, and the network (e.g., SIPRNET). The IERs that define data communications for individual networks to be assessed by CAM are created using the Lotus Approach 97 database application.

The other major component of CAM is the model of the existing or predicted network topology that will be assessed against the associated IERs. The real-world physical and logical network topologies are replicated in the model. The network topology consists of nodes (e.g., routers, switches) interconnected by links (e.g., T1 lines). Nodes represent communications equipment or computing devices and are categorized as processor nodes, router nodes, or switch nodes that process either data packets or voice calls. Links represent the transmission media between nodes, ranging from point-to-point circuits and local area networks to wide area networks. Bandwidth, propagation delay, channel capacity, signaling protocol, route selection, and call capacity constraints are built into the model to simulate the operation of the network.

CAM Development Process

Information Exchange Requirements (IERs). IERs are the representation of distinct information exchanges between any two locations from which a resulting communications load over a network can be calculated. The CAM process uses IERs to model the communications profile expected during a contingency (e.g., crisis situation) or a wartime scenario. Wartime or contingency communications loads are traffic "surges" that are added to predicted ambient traffic in the scenario, providing the necessary information for CAM to produce an accurate assessment of communications adequacy. At a minimum, all IERs are characterized by an originator, a recipient, the time of the exchange, precedence (as applicable), classification, and the particular network or dedicated circuit facilitating the exchange. Voice and video IERs are further characterized by the duration of the call, whereas data IERs are characterized by file size in kilobytes. Where a single product is disseminated to multiple recipients, an IER is developed for each originator-recipient pair.

There are three categories of IERs. The first is interpersonal exchanges. This level includes telephone calls, E-mail, and formal messages among organizations. The second is the transaction between an individual end-user and a remote server, such as a "world-wide-web" or "Global Transportation Network" query and response. The third category consists of automated computer-to-computer or server-to-server transactions that do not involve end-user interaction, and that take place primarily to maintain internal computer functions, such as logistics

transaction downloads or database update transfers. Because of DOD's aggressive exploitation of emerging computer technology, the second and third layer IERs comprise the bulk of the CAM IER load.

Validation of IERs. The validity of IERs is certainly a critical factor in the CAM assessment process. For example, in a recent PACOM CAM NIPRNET assessment, D82 qualified the CAM IER process by performing a correlation analysis between two separate IER sources for U.S. Army communications: (1) the set of Army IERs developed by the D82 CAM team within the scope of the PACOM AOR assessment, and (2) the set of Army IERs developed by the PACOM Army Pacific Commander (ARPAC) through a separate ARPAC review and validation process. The following is the resultant overall correlation between the Army IERs developed by D82 and those developed by ARPAC, for total predicted available bandwidth:

$r = 0.92$; r squared $= 0.85$, $p = 0.0093$.

This finding demonstrates a very close correlation, and supports the validity of the CAM IER development process. It is noted that ARPAC developed their IERs independently of the CAM process five months after D82, and that the communications loading was very similar to that projected by the D82 CAM team.

Network Simulation and Analysis. The IERs that define each communication flow are compiled using a Lotus Approach 97 database application called the Communications Support Planning Tool (CSPT). After the IER files are quality controlled, the final products are used as input to the network topology models built with a selected, commercially available, discrete event simulation tool (COMNET III). The simulation is then run to generate the important network performance measures required for an OPLAN/CONPLAN. The simulation results are used to determine where, when, and for how long any delays, congestion, and blockages will occur, as well as providing the probability of blocking on voice networks. Additional runs can be executed with selectively degraded or failed nodes or links to determine the resultant performance or vulnerability impacts.

CAM assessment results are provided to the customer through PowerPoint presentations, white papers, and animations that display time-phased network performance results. The animations provide for a rapid understanding of the extent of blockage or delays associated with the events/scenario in question. This is made possible by color-coding the results to be shown as either green, yellow, or red (i.e., acceptable, marginal, or unacceptable performance) according to specific mission supportability criteria provided by the customer. In addition, a greater level of detail explaining individual link congestion or blockage, and why it is occurring, is also available for display. This provides both a quick overview of the CAM output as well as a detailed look at problem areas, as desired.

CAM Delivery Schedule

While the CAM process is tailored to each customer, the turnaround time for a typical assessment is 2 to 6 months. The time factor associated with CAM depends on the detail required for the assessment and the availability of the warfighter communities to provide critical

communications information for IER update and development. In the case of MS&A to evaluate projects involving the introduction of new communications technology or systems, the project sponsor and the CAM customer need to agree on the technical and operational assumptions. Other factors that play a role include: a) the level of support received by theater operational experts; b) the availability of information defining peacetime or ambient information products, IERs, and network topologies; c) the level of detail desired by the CAM customer; and d) the number of ongoing communication infrastructure modifications being made in the AOR during the MS&A effort, which may require frequent topology updates.

Summary

DISA's C4I Modeling, Simulation and Assessment Directorate, CINC Support Division (D82) has successfully completed a large number of CAM analyses, including major studies for USCENTCOM and USPACOM, to determine the adequacy of the DII/DISN to support the CINC OPLANs. The success of CAM is evident in ongoing cost-effective communications systems upgrades and development in these AORs. In addition, D82 also successfully completed DII/DISN network impact and vulnerability assessments in support of emerging technologies being implemented in-theater (e.g., EMSS and GBS).

Quantifying the impact of communications network improvements on military operations is a challenging task, as many factors must be taken into consideration to ensure that the analysis process leads to meaningful results. The communication traffic loads must be analyzed against the available bandwidth during normal peacetime operations. In addition, and what is typically much more difficult, is the analysis of the ability of existing or predicted bandwidth to support an increase in communications demand, or any change in a given traffic profile associated with the activation of a wartime or contingency operation. D82's CAM process is the best available method that can proactively quantify projected network traffic using discrete event simulation techniques, and determine where communications congestion and chokepoints will occur during times of conflict, in particular, when the communications demand is shown to be much greater than during routine peacetime operations. Furthermore, the CAM process can determine critical changes or impacts (e.g., link congestion or under-utilization) as a result of introducing new C4I technology or systems in-theater, and determine what effect the new system may have on associated networks or users from different organizations. These analyses provide DOD warfighters and planners with knowledge regarding where additional attention is needed to resolve areas of communications deficiencies or imbalances. Ultimately, all CAM customers benefit by knowing where communications shortfalls are before a "stressed" scenario occurs, or when new communications technologies are introduced. Thus, network owners and users are in a better position to plan for wartime situations, contingency operations, or new communications system development.